APPENDIX C

Knight Piésold CONSULTING

Knight Piésold Ltd.
1400 - 750 West Pender St
Vancouver, BC V6C 2T8
CANADA

Tel: +1 (604) 685-0543
Fax: +1 (604) 685-0147
Fax: +1 (604) 687-2203
www.knightpiésold.com

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SENDER:	Ian Manning	**APPROVED:**	

TO:	Department of Environmental Quality	**FAX :**	(406) 444-1374
ATTN:	Charlie Freshman		
Cc:	John Schaefer, MTMI		
SUBJECT:	MTMI Tailings Embankment – Summary of Stability Analyses		

Charlie,

Design and operation of the Montana Tunnels tailings facility has followed the observational approach, whereby the performance of the facility is continually monitored, and embankment stability analyses are updated on an on-going basis to reflect actual operational conditions. Knight Piésold has carried out several site investigation programs and stability assessments for the tailings facility at various stages of Mine development, as deemed prudent due to operational changes as well as to support various permitting requirements. Results of site investigations, laboratory testing programs, and on-going monitoring have allowed for updating and confirmation of material parameters used in all analyses. A summary of previous stability analyses carried out for the tailing facility is described below, with results provided on the attached Table 1.

The tailings facility was originally constructed by downstream methods, and was permitted to an embankment crest elevation of 5515 feet. A permit amendment was approved in 1990, which allowed for on-going embankment construction by the modified centreline method. This was later followed by a proposal by MTMI to expand the tailings impoundment for increased storage capacity, with an ultimate embankment crest elevation of 5600 feet. A site investigation program and stability assessment was carried out to support permitting of the embankment to elevation 5600 feet, as presented in the Knight Piésold document, "Report on Tailings Area Expansion", Ref. No. 3151B/1, August 1993. This stability assessment included limit equilibrium as well as pseudo-dynamic finite element analyses. Results of these analyses predicted acceptable Factors of Safety and deformations for embankment crest up to at least elevation 5636 feet.

A technical evaluation of the 1993 tailings expansion design was carried out by Water, Waste and Land, Inc. (WWL). Some issues were raised regarding the post earthquake stability of the embankment above elevation 5580 feet. To address these issues, an additional site investigation and laboratory testing program was carried out in 1994, followed by a tailings liquefaction assessment and stability assessment. Results of the work programs and analyses were presented in the Knight Piésold document, "Supplementary Site Investigations and Analyses for Tailings Embankment", Ref. No. 3151B/5, January 1995. This stability assessment included both limit equilibrium and finite difference (FLAC) analyses, to confirm long-term static and post-liquefaction stability for an embankment crest elevation 5600 feet. These analyses demonstrated a good correlation between the results of limit equilibrium and finite difference analysis methods, and both methods resulted in Factors of Safety that exceeded the minimum required values for static and post-liquefaction stability.

A feasibility study was carried out in 2000, to evaluate the viability of on-going operations by means of underground mining following completion of open pit operations. This study included an expansion of the tailings embankment to an ultimate crest elevation of 5620 feet. Updated stability analyses were carried out for this configuration, as described in the Knight Piésold document, "Report on Modified Centerline Embankment Raises", Ref. No. 31315/34-8, March 2000. A detailed site investigation program and liquefaction assessment was also carried out in 2000, to confirm the input parameters used within the stability assessment. Results of this work was presented in the Knight Piésold document, "Report on Site Investigations and Tailings Liquefaction Assessment", Ref. No. 31315/36-3, Dec 2000. The limit equilibrium analyses determined that the embankment would remain stable to at least elevation 5620 feet. Finite difference (FLAC) dynamic analyses were carried out, to estimate the extent of liquefaction during the design earthquake event, and to determine the subsequent displacements of the embankment. Minor crest settlement was predicted under the Maximum Credible Earthquake (MCE); however, there was no risk of overtopping, and the deformations were considered to be acceptable for this extreme seismic event.

Another feasibility study was carried out in 2001, to evaluate an open pit expansion (K-Pit). The proposed pit slope layback would allow for the extraction of additional ore reserves and extend mining operations for almost 4 years. Additional capacity for tailings deposition would require an expansion of the tailings embankment to an ultimate crest elevation of 5640 feet. The proposed pit expansion would also require the construction of a new waste dump along the downstream slope of the tailings embankment. Updated stability analyses were carried out for a crest elevation of 5640 feet, and included the waste dump adjacent to the downstream embankment slope. These analyses were presented in the document "Report on Stability Assessment for On-Going Tailings Deposition" (Ref. No. 31315/37-4, October 19, 2001). Static, pseudo-static (seismic), post-liquefaction limit equilibrium stability analyses

and Newmark displacement analyses were carried out. These analyses demonstrated the significant buttressing effect provided by the proposed downstream waste dump, with Factors of Safety well above the minimum acceptable values for each case, and zero displacement predicted from the MCE seismic event.

We trust this information will meet your current requirements. Please contact myself if you require any additional information.

Regards,

Ian Manning, P.Eng.

Encl.

Table 1 (Rev.0) MTMI Tailings Embankment – Summary of Stability Analyses

TABLE 1

APOLLO GOLD CORPORATION
MONTANA TUNNELS MINE
TAILINGS DISPOSAL FACILITY

MTMI TAILINGS EMBANKMENT - SUMMARY OF STABILITY ANALYSES

Revised: January 8, 2002

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Knight Piesold Reference	Crest Elevation (ft)	Type of Analyses	Case	Slip Surface Direction	Minimum Req'd F.S.	Calculated F.S.	Maximum Displacement (ft)	Notes
KP Ref. No. 3151B/1, Aug 1993	5600	Limit Equilibrium	Static	u/s	1.5	2.2	-	- Analyses also carried out for crest elevations 5575', 5620', 5640'
	"	"	"	d/s	1.5	2.7	-	"
(analyses carried out to support								
permitting of the tailings embankment	"	L.E. & Newmark	Pseudostatic	u/s circular	1.0 or limited displ.	<1.0	0.4	"
to an ultimate elevation of 5600 feet)	"	"	"	d/s circular	1.0 or limited displ.	>1.0	0.0	"
	"	"	"	d/s wedge	1.0 or limited displ.	<1.0	0.3	"
	"	Limit Equilibrium	Post-EQ	u/s	1.1	>1.1	-	"
	"	"	"	d/s	1.1	1.5	-	"
	5600	Finite Element	-	-	-	-	1.3H, 0.3V (d/s)	- Horiz displacement d/s, Vert displacement downwards
	5640	"	-	-	-	-	2.0H, 0.2V (d/s)	- Horiz displacement d/s, Vert displacement downwards
KP Ref. No. 3151B/5, Jan 1995	5600	Limit Equilibrium	Static	d/s	1.5	1.8	-	
	"	"	Post-EQ	d/s	1.1	1.1	-	- Post-EQ F.S. > 1.8 after closure, with drainage of sandy tailings adj. to embankment to achieve partially saturated conditions
(analyses carried out to support								
permitting of the tailings embankment	"	Finite Difference	Static	d/s	1.5	>1.5	-	- FLAC, same geometry and input parameters as limit equilibrium
to an ultimate elevation of 5600 feet)	"	"	Post-EQ	d/s	1.1	>1.1	-	"
KP Ref. No. 31315/34-8, Mar 2000	5620	Limit Equilibrium	Static	d/s	1.5	1.6	-	
	"	"	Post-EQ	d/s	1.1	1.1	-	
(analyses carried out for underground								
mining proposal, for an ultimate	5620	Finite Difference	Post-EQ	d/s	1.1	1.2	-	- FLAC, same geometry and input parameters as limit equilibrium
embankment elevation of 5620 feet)	"	"	Dynamic	d/s	1.0 or limited displ.	<1.0	3.0H, 4.0V	- Horiz displacement d/s, Vert displacement downwards (u/s crest)
KP Ref. No. 31315/37-4, Oct 2001	5640 (1)	Limit Equilibrium	Static	u/s	1.5	3.8	-	(1) Intermediate d/s buttress dump geometry to El. 5525'
	"	"	"	d/s	1.5	2.8	-	"
(analyses carried out for proposed								
K-Pit expansion, for an ultimate	"	L.E. & Newmark	Pseudostatic	d/s	1.0 or limited displ.	>1.0	0.0	"
embankment elevation of 5640 feet,								
and includes d/s buttress waste dump)	"	Limit Equilibrium	Post-EQ	u/s	1.1	2.7	-	"
	"	"	"	d/s	1.1	2.1	-	"
	5640 (2)	Limit Equilibrium	Static	u/s	1.5	4.8	-	(2) Final d/s buttress dump geometry to El. 5640'
	"	"	"	d/s	1.5	3.7	-	"
	"	L.E. & Newmark	Pseudostatic	d/s	1.0 or limited displ.	>1.0	0.0	"
	"	Limit Equilibrium	Post-EQ	u/s	1.1	5.4	-	"
	"	"	"	d/s	1.1	3.2	-	"